This Continuation-In-Part Patent Application has two parent applications. Those parent patent Applications are:

Matzner et al. U.S. Patent Application Serial No. 07/701,931 filed May 17, 1991 entitled OPTIMIZED SPACER ASSOCIATED PRESSURE DROP IN A BWR BUNDLE HAVING PART LENGTH RODS; and,

Dix U.S. Patent Application Serial No. 07/702,644 filed May 17, 1991 entitled SEPARATION DEVICES WITH PART LENGTH RODS.

The specification herein merely combines these two patent applications; no new material has been added.

The claims in this prosecution find origin as follows:

Independent claim 1 is a generic claim finding support from the combined specifications. As this claim has not yet been presented, argument for allowability is presented in the following remarks.

Dependent claims 2-7 are dependent claims taken from Matzner et al. As these claims were not presented earlier, the following remarks includes argument for the allowability of these claims.

Dependent claims 8-14 are dependent claims taken from Dix. Since these claims have a different independent claim, the following remarks contain argument for their allowability.

Independent and dependent claims 15-50 are claims from the original Matzner et al. application. At the close of the prosecution of the parent case, these claims were still under rejection. Accordingly, argument is included in this Amendment Before Examination for their allowability.

Finally, independent and dependent claims 51-71 have their origin in Dix. These claims have no argument presented for allowance -- having been previously allowed in the original Dix prosecution.

This Continuation-In-Part is lodged to obviate any rejection that might otherwise be lodged under 35 USC §102e between the applications if separately issued.

**Previous Action on the Merits**

Claims 15, 22, 28, 35 and 45 (originating as claims 1, 8, 14, 21 and 31 in the original Matzner et al. application) have been rejected under 35 U.S.C. §102(a) and (b) as being clearly anticipated by Ueda or Sakurada.

Ueda is a prior art patent which sets forth as the main point of novelty the increasing section of a fuel bundle channel as the channel goes from the lower portion of the bundle to the upper portions of the bundle. Specific citation has been provided. Attention has been called to:

Column 10, lines 48-56 (reference of the specification to partial length fuel rods and spacers);

Column 7, lines 39-59, column 8, lines 26-38, and column 12, lines 32-43 (reference of the specification to critical power).

Sakurada is a prior art patent which sets forth as the main point of novelty the use of sub-groups of fuel rods within a single fuel bundle. Specific citation has been provided. Attention has been called to:

Column 6, lines 58-68 (reference to part length fuel rods and spacers);

Column 7, lines 51-61, 65-68 (reference to part length fuel rods being disposed adjacent the sub-channels defined between the discrete sub-groups of fuel rods within a single fuel bundle); and,

Column 8, lines 3-15 (reference to separation of the fuel rods, distance between the outermost fuel rods and the surface of the channel box).

Finally, claims 15-50 (originally claims 1-36 of the Matzner et al patent application) have all been rejected under 35 U.S.C. §103 as being unpatentable over Ueda, Sakurada or taken in view of Campbell. It is stated that the claimed combination of the part length fuel rods and spacers are shown by Ueda and Sakurada. Campbell is cited for his reference to swirl vanes to improve critical power; see Column 4, lines 7-9, and 61-71+.

The following remarks will be addressed to claims 1-14 as well. It will be understood that the difference between these claims and those previously pending in Matzner et al. is that in claims 1-14 there is no requirement that the "means for restoring at least some of the pressure drop..." be affixed to a spacer. This means can literally be anywhere in the annular flow regime of the fuel bundle.

In discussing this rejection, Applicants will first summarize the invention as set forth in the enclosed amended claims. These claims will set forth the fact that Applicants' fuel bundle solves a problem which goes unrecognized in the prior art -- the problem that part length rods tend to have critical power problems in the remaining full length fuel rods of the fuel bundle into which the part length rods are included. Thereafter, the amendment to the claims as providing means for restoring pressure drop in the spacers of the upper annular flow regime of the fuel bundle will be set forth. It will be pointed out that Applicants' fuel bundle incorporates for the first time the combination of part length fuel rods and spacers having differing configuration in the upper annular flow regime of the fuel bundle. Specific reference will be made to the serendipity present -- the improvement of overall critical power by the discernable alteration of the fuel bundle spacers in the upper annular flow regime of the fuel bundle.

Thereafter, the main points of novelty of Ueda and Sakurada will be set forth. It will be shown that none of these references includes the employment of the pressure drop available in combination with part length fuel rods to improve critical power. Finally, the referenced portions of each of the specifications of Ueda and Sakurada will be analyzed. It will be pointed out that these references having nothing to do with Applicants' discovery of the problem of critical power caused by the insertion of part length rods. The point will be made that Applicants' insertion of two discrete classes of spacers -- one in the lower region of the fuel bundle and the other in the upper annular flow regime of the fuel bundle (for the restoration of the pressure drop) is an expedient not shown nor suggested by these references.

Finally, reference will be made to claim language. It will be shown that over the references of record, patentability is present. As a result, allowance will be urged.

**The Invention Herein**

First, and in accordance with the Dix et al. Patent 5,112,570, it is known that the insertion of part length rods causes reduced pressure drop. See Specification, Column 7, lines 43-55. This was an original General Electric innovation of the Dix, et al. team.

Further work has been done on the part length rods. A discovery has been made. This discovery is set forth on page 6 under the subtitle "DISCOVERY". Specifically, it has been discovered that the full length rods adjacent to the part length rods tend to have "critical power limitations in the upper annular flow regime of the fuel bundle." It is set forth as determined by experiment that "flow rates around and adjacent the

full length rods may be below average." It is described as causing "transition boiling and critical power limitations."

None of the cited references alludes to the fact that the presence of the part length rods causes on the adjacent full length rods decreased critical power performance.

The improvement which Applicants seek to patent is the restoration of the pressure drop obtained by the insertion of the part length rods. This restoration occurs by virtually anything interior of the fuel bundle in the upper two phase region of the fuel bundle, including anything attached to the spacers in the upper annular flow regime of the fuel bundle. For example, spacer pitch can be increased. Further, the length of the individual spacers can be increased. Swirl vanes or regular vanes can be used.

On page 10, lines 18-30, an example is given. By analyzing the example, the Examiner will understand that serendipity is clearly present.

It is pointed out that in a 9x9 array of fuel rods, with 8 part length rods distributed throughout the bundle, pressure drop improves 8%. Unfortunately, critical power loss due to the presence of the part length rods may in the range of 2-4%.

Enter, Applicants' improvement. Specifically, spacer pitch is increased so that pressure drop is restored in the amount of 0.8 psi. Critical power suddenly improves by as much as 12%. Thus, presuming an original loss in critical power of 2%, the addition of Applicants' structure results in a 12% improvement, or a 10% overall improvement of critical power from a fuel bundle having nothing but full length fuel rods. That is to say, comparing this fuel bundle having part length rods with restored pressure drop to a fuel bundle with only full length

rods, critical power performance of as much as 10% over conventional fuel bundles with full length rods can result.

It is to be noted that there still remain 0.4 psi of beneficial pressure drop.

**Claims Summarized:**

Applicants' claims stand amended.

A first group of claims (1-14), includes anything within the fuel bundle in the annular flow regime which is within the spacer that restores the pressure drop.

A second group of claims (15-50) is directed to the spacer attached concept of the Matzner et al. Patent Application.

Specifically, two groups of spacers are utilized in these claims. The so-called first group of spacers is in the lower region of the fuel bundle. These spacers are conventional.

A second group of spacers is utilized. This group of spacers includes "means associated with at least some of said second group of spacers in the upper annular flow regime of said fuel bundle for restoring at least some of the decreased pressure drop realized by said part length fuel rods whereby critical power performance is achieved at said fuel bundle having said part length fuel rods."

Stated in other words, and taking the case of a fuel bundle with the channel removed, the invention should be rather complete in its structure. Simply stated, fuel rods held together in a fuel bundle by at least tie plates and spacers will be present. The fuel bundle will incorporate a number of part length rods. Further, the fuel bundle will have two groups of spacers.

The first group of spacers will be at the bottom of the fuel bundle. These spacers will be normal and have the regular separation.

The second group of spacers will be different. They will include a spacer array having the required means to restore the pressure drop that was achieved when the part length fuel rods were added to the fuel bundle. This means can include spacers on a decreased pitch, spacers with vanes incorporated thereto; spacers with swirl vanes; spacers with increased height; etc.

In other words, the combination of the part length fuel rods and the two differing classes of spacer -- with the annular flow regime spacers being specifically designed to re-introduce pressure drop -- will be present.

Finally, steam separation devices are set forth as claims 51-71. These claims have been allowed in their original prosecution from the Dix patent application.

**Prior art analyzed**

Ueda shows a channel for a fuel bundle. The channel for the fuel bundle set forth in Ueda has a tapered interior. The tapered interior tapers from a relatively small section adjacent the bottom of the fuel bundle to a larger section adjacent the top of the fuel bundle.

As the Examiner points out, the reference includes part length rods. It is set forth in Ueda that this reduces the speed of two-phase flow axially downstream and suppresses the pressure loss. See Col. 2, lines 62-69 Ueda.

Nowhere does the reference set forth the critical power limitation caused on full length rods adjacent part length rods because of the presence of the part length rods.

Further, nowhere does the reference propose restoration of the pressure drop so that critical power may be improved.

Analysis of the sections cited by the Action is instructive:

Column 10, lines 48-56 of the Ueda refers to partial length fuel rods and spacers. This portion of the reference dictates the preferred location of the part length rods. These are in the second row and second column of the matrix. The point is made that the pressure loss is "improved."

Column 7, lines 39-59, column 8, lines 26-38, of the Ueda reference refers to the effect that the upwardly expanding channel of Ueda has (supposedly) on the passing coolant. Specifically, the statement is made that since the coolant has an expanded volume through which the fluid flows, decreased coolant speed with improved critical power will result.

Without deciding the merits of this statement, Applicants will point out that this is contrary to their own findings -- at least in the case where the fuel bundle does not have an expanding channel area to the upper portion of the fuel bundle. Specifically, Applicants have discovered that the presence of part length fuel rods causes critical power to be decreased. In other words, this section of the specification teaches away from Applicants' discovery.

Referring to Ueda at column 12, lines 32-43 refers to the standard advantages caused by the insertion of part length fuel rods in a bundle having full length fuel rods. These are improved reactor shut down margin, axial power shape flattening, reduction of pressure drop in the upper two phase region of the fuel bundle, and improvement of the void fraction. No statement suggests the worsening of the critical power limitations or how this decrease in critical power can be improved.

Having analyzed Ueda this far, it can be seen that Applicants' discovery of a critical power problem with the introduction of part length fuel rods as well as the solution to that problem is nowhere suggested.

Sakurada et al. is a similar reference. Simply stated, Sakurada sets forth as its primary point of novelty the placement of the fuel rods with varied inter-central distance. This varied inter-central distance is the spacing between various sub-groups of fuel rods in a fuel bundle assembly within a channel. The primary purpose of the variation of inter-central distance is an effective improvement of the moderator density reactivity coefficient and to obtain generous thermal margins during operation. The use of gadolinium is claimed to be reduced.

In several of the embodiments, part length rods are set forth. Again, the reference does not set forth a discovery that the insertion of the part length rods can cause critical power problems in adjacent full length rods.

Further, the reference does not suggest restoring at least some of the pressure drop in order to obtain Applicants' serendipitously improved critical power.

Sakurada at Column 6, lines 58-68 points out that fuel rods in the middle of the 9 by 9 sub-groups naturally have the other adjacent fuel rods closely spaced. This being the case, it is recommended that this middle fuel rod be a part length fuel rod. Again, there is no reference to the fact that the presence of the part length fuel rod can cause critical power problems. Further, there is no suggestion as to the solution of this problem.

Sakurada at Column 7, lines 51-61, 65-68, the corner construction of a fuel bundle having the sub-group construction is set forth. Specifically -- and if the sub-groups are located in a channel corner -- it is recommended that the fuel rod which is both located in the sub-group corner and the channel corner be a part length fuel rod.

First, it is said that this construction causes "the flux of the coolant in the subchannels" to be increased and the "critical heat flux (critical power) . . . increased."

Secondly, the claim is made that the critical power is increased by placement of the part length rods in these corner locations. Again, there is no reference to either Applicants' discovery or Applicants' proposed solution.

Sakurada at Column 8, lines 3-15 attempts to set forth how to identify in the sub-group construction, those fuel rods having critical power problems. This is said to depend upon:

a. the pitch of the separation of the fuel rods; and,

b. the distance between the outer fuel rods and the surface of the channel box.

Specifically, when these cited sections of Sakurada are analyzed, one thing is apparent. Nowhere do they suggest or set forth that part length fuel rods can be the cause of critical power decrease. Further, nowhere to they suggest as to how this problem can be solved.

Finally, reference is made to the Campbell reference. In the Campbell reference, admittedly, swirl vanes are shown. Applicants submit that this reference is not as clear as to the advantages of swirl vanes as the assignee's herein own Johansson U.S. Patent 4,913,895 issued April 3, 1990 entitled Swirl Vanes Integral With Spacer Grid (cited to the Examiner in the Specification).

However that may be, again, Campbell includes no suggestions that the insertion of part length rods may cause critical power limitations on the full length rods adjacent the part length rods. Further, it is nowhere suggested to suppress this limitation by restoring the pressure drop. There is no suggestion that when this is done, critical power will be

improved over the case of a fuel bundle having nothing but full length rods. It is noted in passing that Campbell relates to a steam reactor; it does not relate to the two phase water and steam reactor used herein.

**Claim Language**

Referring to the claim language now extant, it is submitted that specificity is present. Specifically, it is pointed out in each of the claims that the use of part length rods results in pressure drop. As the improvement herein, it is specified in each case that this pressure drop be in at least some measure used to improve critical power. The pressure drop is linked in a whereby clause to require that critical power be improved.

It is submitted that in the claims, a construction is set forth which is novel over the prior art. Specifically, the fuel bundle must have full length fuel rods and a plurality of part length fuel rods. These full length and part length fuel rods must be braced by two classes of spacers. A first class of spacers are those spacers in the lower region of the fuel bundle. The second class of spacers is found in the annular flow regime of the fuel bundle. These spacers have means associated with them to cause pressure drop. This means can include a decreased spacer pitch, vanes attached to the spacers, swirl vanes attached to the spacers, spacers of increased height or thickness or the equivalents thereof (pursuant to the means claim limitation of 35 USC §112).

The claims originating from the original Dix Patent Application all refer to "steam separation". These claims have been previously allowed (See claims 51-71).

## CONCLUSION

It is submitted that this case is in condition for allowance. Invention herein has been based both on the discovery that part length fuel rods can themselves cause a loss in critical power capability. Having made this discovery, the solution is also presented. Specifically, by making the spacers of the upper annular flow regime of the fuel bundle recapture the pressure drop obtained by the insertion of the part length fuel rods, critical power is improved. As has been made clear by the example, this improvement exceeds that critical power margin present when only full length fuel rods are utilized. Simply stated, by returning pressure loss to the upper annular flow regime of the fuel bundle, a critical power margin is achieved that would not be otherwise be present. In short, a surprising result is achieved.

In view of the foregoing, Applicants believe all claims now pending in this application are in condition for allowance. The issuance of a formal Notice of Allowance at an early date is respectfully requested.

Before the first Action on this case, the courtesy of an interview with Mr. Robert Schroeder, Reg. No. 28,806, Patent Counsel, General Electric Nuclear Energy, is requested. Mr. Schroeder can be reached at (408) 925-2707 to facilitate timing of this interview.

Respectfully submitted,

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